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1997 DUTCH ELM DISEASE BIOASSESSMENT FOR THE DISTRICT OF COLUMBIA

USDA FOREST SERVICE
MORGANTOWN, WEST VIRGINIA
FOREST HEALTH PROTECTION

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ABSTRACT

Dutch Elm Disease (DED) is a debilitating and often acute fungal disease of most elm species including the native American elm (Ulmus americana), which is one of the most severely affected. The disease agent is a fungus (Ceratocystis ulmi) which grows and reproduces within the vascular xylem of elm wood. The DED fungus is inadvertently inoculated into healthy elm wood, usually within twig crotches, by the feeding activities of the smaller european elm bark beetle (Scolytus multistriatus). The growth of the fungus within vascular tissue in most cases rapidly leads to tree death.

The disease was first reported in the port cities of New York and Cleveland, OH in the early 1930's and traced to elm veneer logs imported from Europe. The disease presently extends throughout all areas of the US, Europe, and Asia where elms occur naturally. DED was initially observed in Washington, D.C. in 1947 and at a time when over 30 thousand American elms were present. Today less than 10 thousand elms remain and the disease still strongly manifests itself within the district.

Many control measures such as insecticides, tree injected fungicides, beetle pheromone traps, pruning, and most importantly sanitation (prompt removal of DED dead and dieing trees) have been used to abate DED spread in the Washington, DC area. However, due to increasing budgetary cutbacks over the past several years, most control measures, including diseased tree removal, were not regularly practiced. Today, nearly 800 elms diagnosed with DED since 1994 remain untreated and standing. These trees have become prime habitats for beetle and fungus reproduction. It is presently imperative that these elms be removed immediately within the district area.

In recent discussions with the NPS and the US Forest Service, the District Division of Tree Maintenance and Landscaping (TD) presently realizes that the 94 through 97 backlog of elms previously confirmed dead or moribund should ideally be removed by April 1, 1998. Since theoretically only one beetle caring one fungal spore can produce a disease condition in an individual elm, complete and rapid sanitation is only biologically reasonable. However, due to the amount of backlogged trees and recent fiscal restraints, total tree removal might not be possible by this date. Since beetle flight begins toward the later part of April and continues relatively uninterrupted through October, disease development over expected values (without DED residual trees) within the district will increase in direct relation to the remaining backlogged trees. It will then be necessary to expand and improve the upcoming DED surveys to accommodate and determine the extent of increase in DED development due to the unremoved diseased trees.

DUTCH ELM DISEASE BIOLOGY

Dutch Elm Disease (DED) is a vascular system disease of all elm species including the native American elm (Ulnus americana). A fungus (Ceratocystis ulmi (or the DED fungus) is spread or vectored form dead or dieing elms to healthy elms principally by the smaller european bark beetle (Scolytus multistriatus) to healthy elms.

The bark beetle utilizes diseased altered outermost branch and stem wood for breeding and brood chamber development. Eggs are laid adjacent and along the vertical oriented adult chamber. Following egg hatch, developing larvae channel horizontally utilizing the wood as food substrate. Each larva then forms a pupal chamber at the end of its horizontal feeding gallery and pupation occurs 6 weeks later. Immediately following pupation, adults emerge form small (1-2mm dia) exit holes in the elm bark.

While emerging, the beetle inadvertently carries infectious spores prolifically produced by the DED fungus to healthy (non-infected) elms. While feeding in twig crotches of healthy elms, the beetle inadvertently introduces the fungus (spores) into the elms vascular system. Fungal spores can easily travel throughout the elm vascular system, become attached to the numerous xylem elements, and subsequently germinate. Fungal structures develop called hyphae which rapidly grow throughout the vascular system and readily occlude the elms vascular xylem elements. In addition to hyphae, infected elms produce gum-like substances in often futile attempts to "wall-off" the fungus. This process technically called tyloses restricts the fungus but also permanently debilitates xylem function.

Any additional stress factor including drought, other elm colonizing insects, fungi, or bacteria can predispose the elm to rapid colonization by the DED fungus. Once fungal entry has commenced, the tree (depending on other stress factors and natural resistance) begins to die and becomes suitable for beetle breeding and brood development (Manion, 1991: Appendix A). The dieing tree also becomes a suitable environment for development of fungal fruiting bodies which consist of masses of spore heads sometimes located on staks and called coremia. Adults of both sexes carry spores to healthy elms and this cycle is usually repeated twice in the Washington, D.C. area with late summer produced beetle larvae overwintering. Adult emergence occurs continuously from late April through September (Appendix B).

DED DIAGNOSTIC CRITERIA and THERAPY (GENERAL)

Field diagnostics consists of rating elm crowns for percent crown branch dieback characterized by leaf yellowing/browning and wilting. Certain percentages of crown dieback or symptom development are expected each year as the disease progresses on elms not therapeutically treated (Table C, below) (Lanier, 1984).

TABLE C. Symptom development in mature 20-30" diameter American elms.

Year of Inoculation	Inoculation Type Beetle Transmitted infection (a)
Year 1	1-10 percent crown symptoms
Year 2	10-80 percent crown symptoms
Year 3	30-100 percent crown symptoms
Years 3 or 4	Tree Death

(a) Root graft transmitted infections are more deletorius and can kill trees with 1-2 years following infection.

Biological confirmation of DED is possible only when diseased branch or stem samples are diagnosed for the fungus Ceratocystis ulmi using standard laboratory protocols. Surface sterilized elm tissue extracts are plated on PDA agar medium and signs of DED fungal growth (structures called coremea) are monitored on these plates. Studies (Lanier, 1984) have shown that elm crowns exhibiting 1-10% DED crown symptoms can be effectively treated (Table D, below) with fungicide injections and/or pruning.

TABLE D. Results of Therapeutic Treatments for Dutch Elm Disease

Washington, D.C. 1980-1983	TREATED	CURED	PERCENT CURED
Current Year	44	39	88.6
Second Year	18	10	55.5
Root Graft	3	0	0.0
TOTAL	65	49	75.4
Syracuse, N.Y. 1975-1983			
Current Year	19	17	89.5
Second Year	15	8	53.3
Root Graft	1	0	0.0
TOTAL	35	25	72.9

Fungicies such as Arbortect(R), Alamo(R), Linosan(R), Phyton(R), and Fungisol(R) have proven to be effective during early symptom development. Equally effective or in combination with fungicide is pruning symptomatic branches from trees and removing at least 10 feet of clear wood beyond the visual presence of the fungus. Fungal colonization becomes directly evident diagnostically by peeling branch or stem bark tissue and exposing the xylem wood. Dark, contrasting staining of the xylem wood by the fungus is then

easily observed. Even elms with 10-30% DED crown symptoms are treatable but with less success. Treatments of elms with crowns symptoms greater than 30% or when the fungus presence is observed in stem tissue, are futile. These trees should be removed immediately.

DED BIOSSESSMENT WITHIN THE DISTRICT OF COLUMBIA

HISTORY, SURVEY/SAMPLING, THERAPY, ASSESSMENT, CONTROL in the DISTRICT REGION

HISTORY

In 1947 DED was first observed within the district and has remained the sole factor for rapid elm mortality (Sherald, pers. comm.). In 1959 38,250 live elms were counted within the district. DED progression up until the early 1970's was low with yearly elm mortality rates at only approximately 1.0%. However, in the mid-70'S disease incidence began to increase to as high as 7% between 1980 and 1982 (Lanier, 1984). In 1983 only 17,000 original elms remained in the district. Today, as the disease still progresses, less than 10,000 of these original American elms are still disease free. An additional 2,500 healthy elms, however, can be found within district areas maintained by the NPS .

DED SURVEY/SAMPLING TECHNIQUES USED BY THE DC TREE AND LANDSCAPEING DIVISION

Surveys for DED are conducted yearly by TD and essentially consist of trained TD personnel that observe individual elms for DED symptoms. Observations from a vehicle for branch tip flagging or yellowing with characteristic leaf wilt. Due to the demanding urban driving conditions, most diagnostic responsibility is delegated to the passenger observer. When a tree with any degree of symptom expression is spotted by the observer, a symptomatic branch specimen is taken using a pole pruner.

All sampled trees are immediately tagged with small 1X2in aluminum tags containing the date when the tree was symptomatically diagnosed with the disease, it's location (which includes the street name), distance form street intersections, and a specific tree number. Surveys usually begin June 1st and, utilizing 1 vehicle, all city streets, greenspaces, and privately-owned trees are individually observed and by August 1.

An extensive survey of all district trees, including elms species, was done in 1971 through 1975. ~~A record history of all~~ tree species, tree conditions, maintenance, or past therapeutic treatments have been recorded on all individual trees since this time. A record history was established at this time delineating specific DC streets as "elm strrets" or streets with predominant numbers of elm species (Appendix C).

Branch samples collected from individual disease diagnosed elms are packaged by the survey crew and sent to the UDC laboratory in Washington, D.C.

If positive results are obtained in the laboratory, tags are retained on individual trees. Conversely, tags are removed from trees when samples prove negative for the DED fungus and trees are then assumed to be DED free. Elms found in district greenspaces as well as privately owned elms also are similarly diagnosed and tagged. Using this method all the district elms are surveyed, and if necessary, sampled and tagged yearly. Symptom progression, however, is not re-examined on previously tagged trees. A currant list of tree species found within the district area is provided here (Table A below).

TABLE A. DISTRICT OF COLUMBIA PRIMARY STREET TREE SPECIES

Tree Species	Common Name
Acer rubra	Red maple
Acer platanoides	Norway maple
Acer saccharum	Sugar maple
Quercus rubra	Red oak
Quercus palustris	Pin oak
Quercus phellos	Willow oak
	Sawtooth oak
Quercus cuccinea	Scarlet oak
Ginkgo biloba	male Ginkgo
Gleditsia triacanthos	Honey locust
Platanus occidentalis X Platanus orientalis	London planetree
Pyrus	Redspire pear
Tilia americana	American linden
Tilia cordata	Littleleaf linden
	Silver linden
Ulmus americana	American elm
	Aygustine elm
Ulmus parvifolia	Chinese elm
Zelkova serrata	Japaneese zelkova

THERAPY

Two therapy methods are presently employed by the city. One involves the attraction and capture of the adult emerging smaller european bark beetle, Scolytus multistriatus by using pheromone traps. Approximately 118 traps are placed within district in areas adjacent to but not dominated with elms.

TD agrees that the most single important DED preventive procedure, however, involves tree removal of dead and dying elms (especially elms with greater than 30% DED crown symptoms). TD has until 1994 removed all trees within 3-4 years following initial symptom development. Since 1994, however, tree removal sanitation was not possible or slow within the district due to budgetary cutbacks. Consequently, a backlog of trees is present today (Table B Below) and consists of standing dead or moribund elms trees found in TD supervised areas within the district. This data was compiled by TD survey crews and represents the most recent bioassessment of DED.

TABLE B.

BIOASSESSMENT OF DED IN THE DISTRICT OF COLUMBIA

Dutch Elm Disease Diagnosed Trees by Quadrant and Year District of Columbia

Acres	SE 6,600	NE 7,700	NW 12,600	SW 950			
YEARS					TOTAL (by year)	#Remain	%
1994	69	76	135	2	282	14	5
1995	78	89	163	4	337	168	50
1996	84	70	123	4	281	253	90
1997	102	120	133	7	358	354	99
TOTAL (by quadrant)	264	279	419	15	977	789	

Table B describes the number of trees diagnosed with DED each year from 1994 through 1997, in what district quadrant location trees were located, and number and percent trees remaining that have not been removed. From 1994 through 1997, 789 trees positively diagnosed with DED remain standing within district tree maintenance supervised areas. Standing trees of major concern are those diagnosed in 1996 and 1997 for DED where 478 still remain on city streets. All disease trees, but especially '96 and '97 trees are potential sources for the DED european beetle breeding habitats.

DED TREE REMOVAL OPTIONS

OPTION 1) Select All Diseased and Dead Elms For Removal By April 1, 1998

Consequence: Removal of all diseased and dead trees would eliminate the emergence of the overwintering beetle populations from dead and moribund elms. This also precludes the elimination of subsequent beetle generations which would be active in feeding, mating, and brood chamber development throughout the spring and summer. However, it must be cautioned that despite removing all DED diagnosed elms by April 1, some degree of beetle emergence still would be expected. This would occur from those trees that were not diagnosed with DED during the 1997 survey because of low levels of symptom development at that time. Eliminating all the backlog DED elms by April 1 also provides the opportunity to eliminate hazard, nuisance, and trees trimmed by Pepco first with no preference given to diseased or dead DED elms.

OPTION 2) Select 1/3 to 1/2 of All DED Elms To Be Removed By April 1, 1998 and Remove the Remainder By June 1, 1998

Consequence: The two most intense periods of beetle emergence in the district area occur in April and May and in July and August which represent the overwintering and second beetle generations, respectively (RTF). A certain amount of disease increase in healthy elms is expected due to the feeding activities of the overwintering generation. However, brood chamber construction for either a third or overwintering generation would be abated with the removal of the backlog elms. Lanier (LS) suggests that second generations have greater densities of approximately twice that of the first or the overwintering generation. This might suggest that despite not removing all diseased and dead elms by April 1 (Option 1), Option 2 might still eliminate the greater majority of the 1998 emerging beetles. However, it must be cautioned that elms are most easily and rapidly infected in the spring season and at a time when xylem elements are widest.

OPTION 3) Remove Elms Consistently But Over a One Year Period and With No Specific Time Frames

Consequences: Both spring and summer beetle generations will be at least partially available depending on removal schedules and disease incidence will be even higher than with option 2. Since at any one time more both more live and DED elms will be available for beetle activities disease incidence will increase dramatically over that of option 2.

OPTION 4) Remove Only Hazard and Nuisance DED Elms

Consequence: This provides the beetle with the most abundant and widespread habitat for feeding, mating, and breeding and would directly cause the greatest disease spread and incidence.

US FOREST SERVICE RECOMMENDATIONS

1) Follow DED Tree Removal Option 1.

Utilize FS/TD contract along with private contracts and remove all moribund and dead elm trees. This would best expedite timely removal of DED elms that have become hazard trees. The FS/TD contract should be used only for the removal of elms. The order of removal as to year of tree death or tree location is not essential but providing that all DED elms are removed by April 1.

maybe you should just Rec. option 2. Save dollar wise, it may be the most feasible. ?

2) Follow DED Tree Removal Option 2 (if (Option 1 is not feasible)

Provides the best alternative if realistically only 1/3 of DED can be removed by April 1 but allows for a degree of disease increase over option 1. It is recommended, however, that all attempts be made to remove as many trees as possible before April 1, 1998. Diseased incidence can be abated at certain locations even with option 2 if DED elms within these locations are eliminated first. We suggest that these initial 1/3 of the backlog elms be located near the monumental core and NPS areas within the district. The remaining 2/3 or the DED elms under FS/TD contract should be removed removed at greater distances away form the monumental core area. Also if option 2 is followed, only DED diagnosed in during the 1997 summer survey should be removed with the initial 1/3 elms to be re3moved by April 1 under the FS/TD contract.

3) Do Not Follow Option 3 or Option 4

These options would accomplish little to abate DED within the district area. Essentially these options would simply aid other non-DED tree removal programs. Elm trees, because of their preponderance, are also removed due to hazard, nuisance, line interference, and for general tree replacement. At best options 3 and 4 allow for a relaxed and economically feasible scheduled of the removal of DED elms. If at least 1/3 of the DED trees cannot be removed by April 1, then trees topped by Pepco should be given consideration because a greater amount of trees can be removed and 2) trees should be removed that present the greatest impact for DED spread into the monumental core area. Also, 1997 DED designated trees should be previously targeted for removal.

4) Present DED survey methods used by TD should be amended to include:

a) surveys should be done twice yearly. The first survey commencing June 1 and ending July 15 would include DED symptoms initiated by the feeding activities and subsequent fungal introduction of the overwintering beetle generation. Also infection symptoms missed during the previous years survey would be readily spotted during this time. The second survey would occur between between September 1 and October 15 and would include disease symptom expressions initiated by the second or summer generation as well as symptoms not observed during the first survey;

b) expand survey crew members to accommodate inspecting all DC elms twice per year and within the specific recommended time frames;

c) surveys should be done on foot with 2 observers on each side of the street rating individual elms, ie., from two district distances and tree crown aspects;

d) elms should be evaluated for any degree of DED symptom expression and stricter observations made on apparent disease-free trees that in fact may harbor small, initiating infections and showing less than 10 percent crown symptoms.

5) Public Involvement in Understanding DED Symptom Expression and Disease Development in the DC Area Should Be Initiated.

Community action groups to "save" the elms should be organized, encouraged, and provided with guidance and suggestions by trained personnel as to methods of disease recognition and treatments. Information gathered by these citizen groups will help augment present survey, therapeutic, and pruning endeavors.

6) Chemical therapy and/or pruning should be an important alternative Option to Tree Removal in the Future.

The more intensive DED surveys possibly coupled with community action suggested above will provide more current/timely diagnoses, whereas, large numbers of trees will become available for therapeutics. Lanier (LS) suggests that trees with less 10 percent DED crown symptoms can be treated effectively and a even a 75 percent survival rate can even be realized with trees showing 10-30 percent crown symptoms. Chemicals such as Arbortect(R), Dcbacarb(R), Linosan(R), Alamo(R), Fungisol(R), and Phyton(R) and/or in addition to pruning at least 10 feet from fungal symptoms have been measures effectively used within the district area in the past by TD and the NPS.

7) Continue Using Beetle Pheromone Traps

Attract insects to areas not predominated by elms. Presently 218 traps are placed yearly throughout the district. An increase in trap numbers accompanied by timely removal of non-treatable DED elms would greatly effectualize present trapping efforts.

8) CAC treatment

Should be considered in greenspace areas within the district and for trees where removal may be difficult or trees scheduled to be removed cannot be done in a timely fashion (see Appendix D for more information on time schedules for removing DED trees within the district area).

9) Utility of Resistant Elms

American elms varieties such as the Jefferson, Valley Forge, Liberty, new Harmony, and Princeton should be grown at nurseries were adequate stocks can be maintained as elm replacement trees. Elm seedlings also should be inoculated at the nursery or when outplanted with appropriate commercially available mycorrhizae. Inoculation with mycorrhizal fungi will stimulate better growth and survival when transplanted into the urban environment.

10) Coordinate Data Form DED Surveys With 1998 Elm Yellows Surveys

Elm yellows is an MLO organism that also infects the vascular system of many elms. Surveys will soon be conducted in close proximity to the district in Maryland and along the C and O Canal Trail on NPS lands. Rate of disease geographical movement and epidemiology should be intensively monitored as this disease progresses to the district area. Understand the impact of the elm yellows disease on DED progression as possibly a predisposing or acceleration factor. Also plan to study the effects of this disease on the resistant American elms species found in the district.

11) DED diagnosed elms should be continuously monitored

Continue to survey elms for DED symptoms until they are removed. DED is a rapidly infective disease and trees only survive at most only a few years. Important data can be derived from understanding how crown symptoms develop over short time periods. It would be informative to correlate this information with disease progression.

DED MANAGEMENT RECOMMENDATIONS by the TASK FORCE

The Management Program for the Perpetuation of the American Elm Tree in the National Capital was established by the Save The Elms Task Force in 1983. This group, consisting of the National Park Service, Department of Defense, Smithsonian Institution, and the General Service Administration of the District of Columbia are all dedicated to slowing and maintaining elm mortality within the district to prescribed and low levels.

Levels of mortality are dependent on 2 types of prescribed treatments respective of 2 distinct management zone types within the district (Elms Task Force Management, 1993). Zone 1 includes elms that are intensively managed and includes the Monumental Core. Within this zone elms are to remain the dominant species and annual elm mortality is to be managed at levels of 1% or less. New and replacement trees species within this area are predominantly elm varieties.

Less intensive management techniques are employed within zone 2. Essentially zone 2 areas encompass all of the district not including and immediately surrounding the monumental core area. This zone also includes all prevately owned elms within the district. The management goal in Zone II is to maintain annual DED loses to 3% or less and tree replacement does not have to be elm. However, elm replacement is strongly suggested on streets that have historically been associated with elms (designated as elm streets) within the distrit (Appendix C). Specific management plans for each zone are provided in Appendix A. Essentially, the task force clearly delineates the necessity for annual tree crown inspections and stresses both sanitation and therapeutic treatments to abate the spread and advance of the disease.

GERALD LANIER STUDY

This last but most extensive district DED survey and study described elm tree conditions and management practices from 1976 through 1984. This report and select studies by Lanier and others are described in this assessment because: 1) similar problems that existed over ten years ago within the district are present today; 2) recommendations as to therapeutic, cultural, and prevention directly are applicable to present DED conditions within the district; 3) the biology and control of DED is concisely explained, applicable, and presently appropriate to the district, and 4) Lanier prescribes and conclusively follows the management strategies prescribed and outlined by the DED Task Force (Appendix D).

In the final and 1984 report, Integrated Management of Dutch Elm Disease in Washington, D.C , Lanier and Jones describe the disease incidence along 21 streets in Washington, D.C. as percent new infections occurring each year from 1979 through 1984. During these years percent yearly mortality averaged 2.8%. With an adjustment made as to the actual number of healthy trees present when the DED Task Force was initiated, Lanier describes similar percentages reported by TD. He forewarns, however, that the percentages reported by TD actually lag by 1 year due to less stringent survey methods done by TD.

Lanier strongly suggests that elms are examined by walk surveys where trees can more closely be observed for the first signs of DED and which is difficult to do by TD's car survey (this would eliminate the yearly lag period mentioned above). Lanier suggests that with trees 20-30 inches in diameter, disease development from a single point/source beetle inoculation would result in 1-10% crown symptoms. In year 2 disease would progress to 10-80 percent crown symptoms (Table C, above).

The greater amount of symptom display is amenable to detection by the car survey but once again infection is reported for the first time most likely 1 year following inoculation. Lanier points out that early and timely diagnosed trees can be therapeutically treated (Table D, above). Also, early diagnosed DED trees can be sucessfully theraputically treated (90% of current year infections are treatable, whereas only 53% success is achieved within the second year of infection.)

Lanier following the DED Task Force Plan suggest the following: 1) only walk type inspection should be done each year whereas full views of the crown are observed for at least 10% symptom expression; 2) that 2 walk-type inspections be done each year between June 1 and July 15 and in September/October (this servers to spot DED symptoms caused directly by the summer generation of the beetle and as a check for infection symptoms missed during the first inspection; 3) trees not therapeutically treated within the year of initial symptom appearance should be injected with cacodylic acid and/or removed (tree removal has lagged as noted by Lanier, Appendix E) within the first year of detection and disease confirmation (April 1 for infections detected in late summer and July 1 for infections detected after April) (a similar time schedule also applies to root graft infected elms)(Appendix D); 4) utilize beetle traps during adult emergence during the spring and summer;

5) develop public announcement and DED description handouts to facilitate early detection; and 6) continue reserch into selecting insecticides and fungicides most suitable for disease control and/or therapy.

It must be emphasised that Laniers work note only follows the disease control guideline prescribed by the DED Work Force Plan but most importantly confirms their merit and applicability.

REFERENCES

Elms Task Force Members 1993. Management Program for the Perpetuation of the American Elm Tree in the National capital. Save-The-Elms Task Force December 1983-June 1993. Unpublished Data.

Lanier, G.N.; Jones, A.H. 1984. Integrated management of Dutch Elm Disease in Washington DC. Unpublished Data.

Agrios, G.N. Dutch elm disease concepts. In: Plant Pathology pp. 327-332.

Smalley, E.B. and R.P. Guries. Breeding elms for resistance to Dutch Elm Disease. Annu. Rev. Phytopathology Society. 1981.

Striclen, M.B. and J.Sherald. Cellular and Molecular Approaches in Dutch Elm Disease. In: Dutch Elm Disease Research. Springer-Verlag New York. 1993.

Hanisch, M.A.(edt.) 1983. Dutch Elm Disease Management Guide. US Forest Service Publication. Bulletin One.

Sherald, J.L. 1993. Demands and Opportunities for Selecting Disease-Resitant Elms. Dutch Elm Disease Research: Cellular and Molecular Approaches. Edited by Marion Stieken and James Sherald. Springer-Vertag New York.

Manion, P. The Dutch elm disease. In: Tree Disease Concepts 1991. pp. 211-216.

APPENDIX A

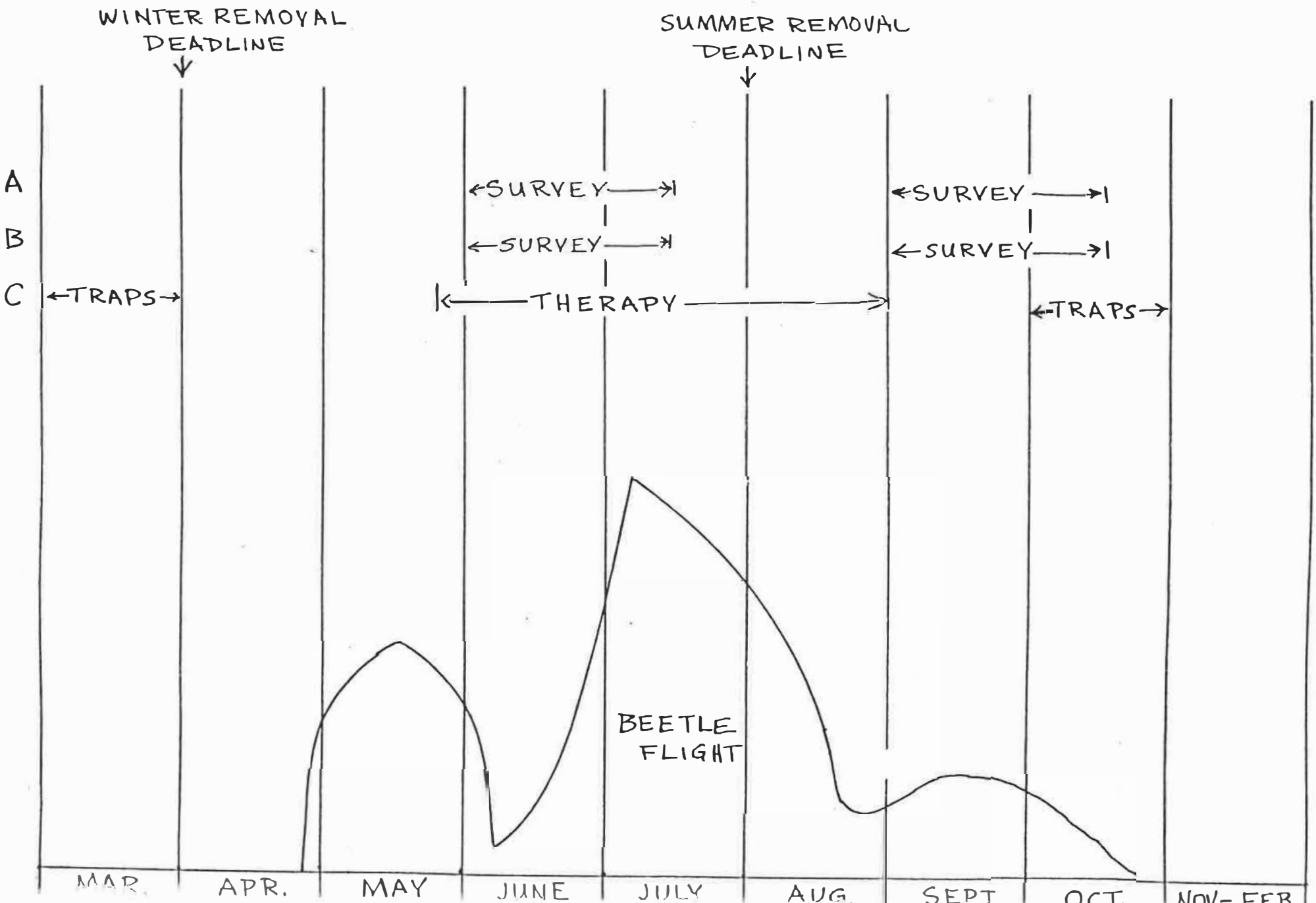
DISTRICT OF COLUMBIA STREETS WITH PREDOMINANT NUMBERS OF ELM SPECIES

NW QUADRANT	NE QUADRRANT	SE QUADRANT	SW QUADRANT
Alaska Ave.	1ST ST	1st St	1st St
Adams Mill Road	6TH ST	4th St	4th St
Allendale Place	7TH ST	11th St	7th St
Arknsas Ave.	8TH ST	14th St	Atlantic St
Belmont Road	11TH ST	15th St	Chesapeake St
Bryant St.	13TH ST	17th St	Danbury St
Butternut St.	14TH ST	19th St	Delaware Ave
Chillum Pl.	15th St	22nd St	Independence Ave
Cleveland Ave.	17th St	23rd St	Joliet St
Chesapeake St	18th St	24th place	South Capitol St
Blagdea Ave	19th St	25th St	
Calvert St	22nd St	30th St	
Decatur St	23rd St	46th St	
Eastern Ave	24th St	49th St	
Farragut Place	26th St	52nd St	
Fordham Rd	30th St	53rd St	
Foxhall Rd	31st St	53rd Place	
Gallitin St	47th St	54 St	
Garfield St	49th St	Alabama Ave	
Gates Rd	53rd St	Atlanta St	
Georgia Ave	49th St	B St	
Grant circle	53rd St	Benning Road	
H St	63rd St	Brandywine St	
Harrison St	Allison St	Buena Vista Terrace	
Hoban Place	Bennett Place	Canal St	
Hobart place	Benning Road	Central Ave	
Illinois Ave	Bladensburg Road	Congress place	
Iowa St	Blaine St	Congress St	
K St	Brentwood Road	Danbury St	
Kalmia Rd	Briant St	Dexter Place	
Kansas Ave	Buchanan St	Dexter Terrace	
Kennedy St	Bunker Hill Road	Firth Sterling Ave	
L St	Central Ave	Fort Dupont St	
Lament St	Chillom Place	Frederick Place	
Linneau Ave	Constitution Ave	Gainesville St	
M St	Deane Ave	Goodhope Road	
MacArthur Blvd	Douglas St	Hartford St	
Macomb St	Downing Place	Hillcrest Drive	
Madison Place	Downing St	Jasper St	
Marietta Place	Eastern Ave	Kentucky Ave	
Mathewson Drive	Evartz St	Livingston Road	
Michigan Ave	Faraday Place	Mellon St	
Missouri Ave	Foote St	Naylor road	
Mornigside Drive	Fort Tatten Drive	New Jersey Ave	
Morrison Drive	Gales place	North Carolina Ave	

APENDIX A CONTINUED

NW Quadrant	NE Quadrant	SE Quadrant
Nebraska Ave	Gallitin St	Portland St
Nevada Ave	Grant St	Potomac Ave
New Hampshire Ave	Hamlin St	Ridge Road
New Jersey Ave	Hoover Road	S St
New Mexico Ave	Ingram St	Savannah St
New York Ave	Irving St	Shipley Terrace
North Dakota Ave	Jackson St	Smith Place
Ontario Place	Jefferson St	South Carolina Ave
Park Road	Kansas Ave	Southern Ave
Peabody St	Kennedy St	Stanton Terrace
Piney Branch Road	Lee St	Southland Road
Q St	Lincoln Road	Suitland Terrace
Reno Road	Madison St	Talbert Terrace
River Road	Michigan Ave	Texas Ave
Roxanna Rd	Montane Ave	Valley Ave
Sheridan St	Mount Olivet Rd	Westover Dr
Utah Ave	N. H. Burrows Ave	Wheeler Road
Van Buren St	New hampshire Ave	
Van Ness St	New York Ave	
Veazy St	Nicholson St	
Waterside Drive	North Carolina Ave	
Wisconsin Ave	Oklahoma Ave	
Woodly Place	Onieda St	
Yuma St	Quackenbos St	
1st St	Richie Place	
4th St	Saratoga Ave	
6th St	Sargent Road	
7th St	Southern Ave	
17th St	Staples St	
18th St	Tennessee Ave	
23rd St	Trinidad Ave	
32nd St	Vista St	
33rd place	East Capitol St	
36th St		
39th St		
45th St		
North Capital St		

Appendix B


WINTER REMOVAL DEADLINE
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BEETLE FLIGHT
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT
OCT.
NOV-FEB

Appendix D

Lanier Suggested DC Street Elm Management
Survey Target Dates

June 1 - July 15 (Foot Survey)	* current year infections * root graft infection * previously missed residual infections
Sept. 1- Oct. 15 (Foot Survey)	* all infections except late season feeding and direct bole attacks
Nov. 1 - Mar. 31 (Vehicle Survey)	* dead tree survey

Tree Removal Deadlines

April 1	* All DED
July 1	* Newly detected DED (non-therapy)
July 1 - Sept. 30	* DED ASAP (non-therapy)

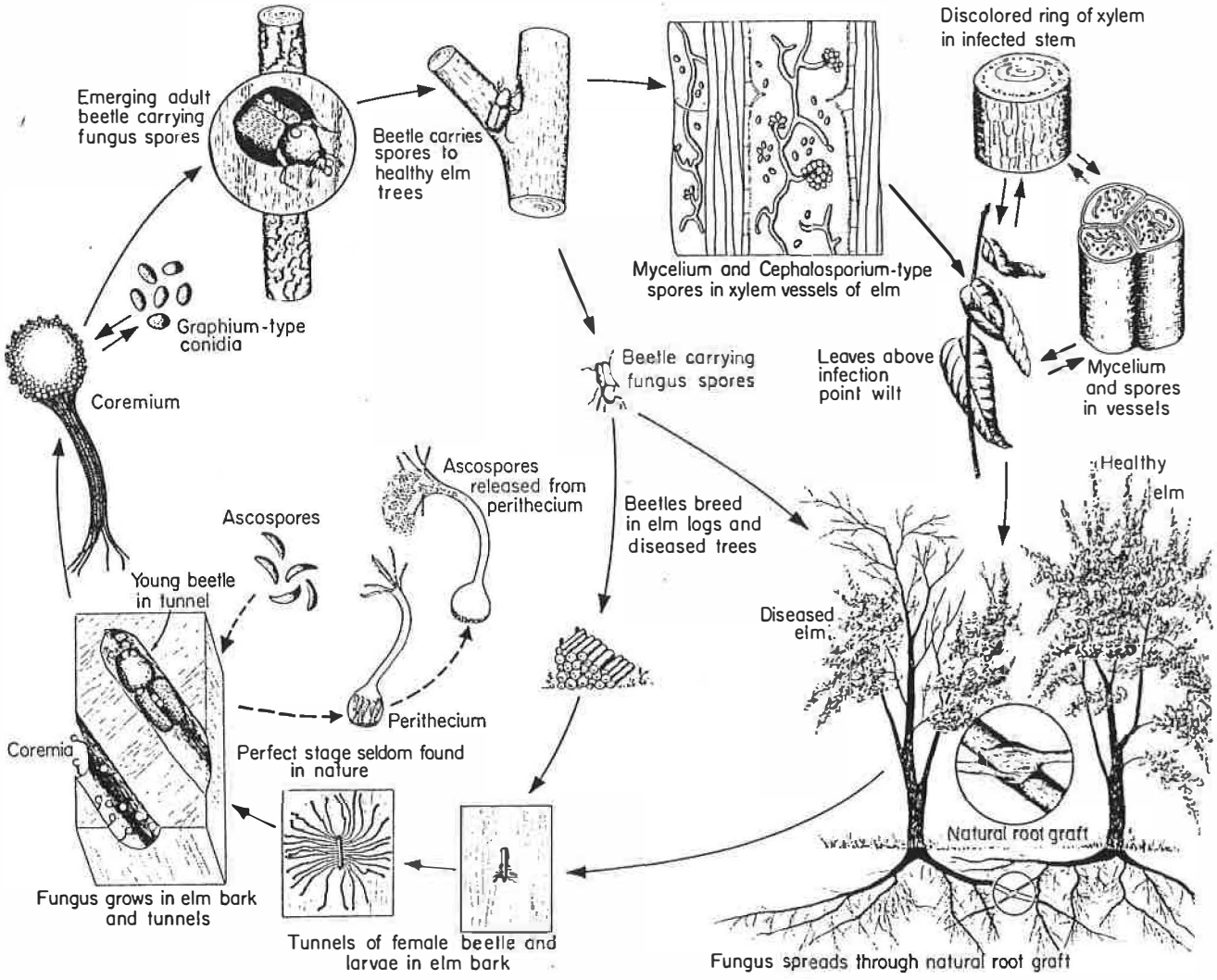
Pheromone Baited Traps

April 1	* Establishment completed by with removal completed in October

Appendix E. MINIMUM NUMBER OF FULL YEARS BETWEEN INFECTION AND REMOVAL (a)

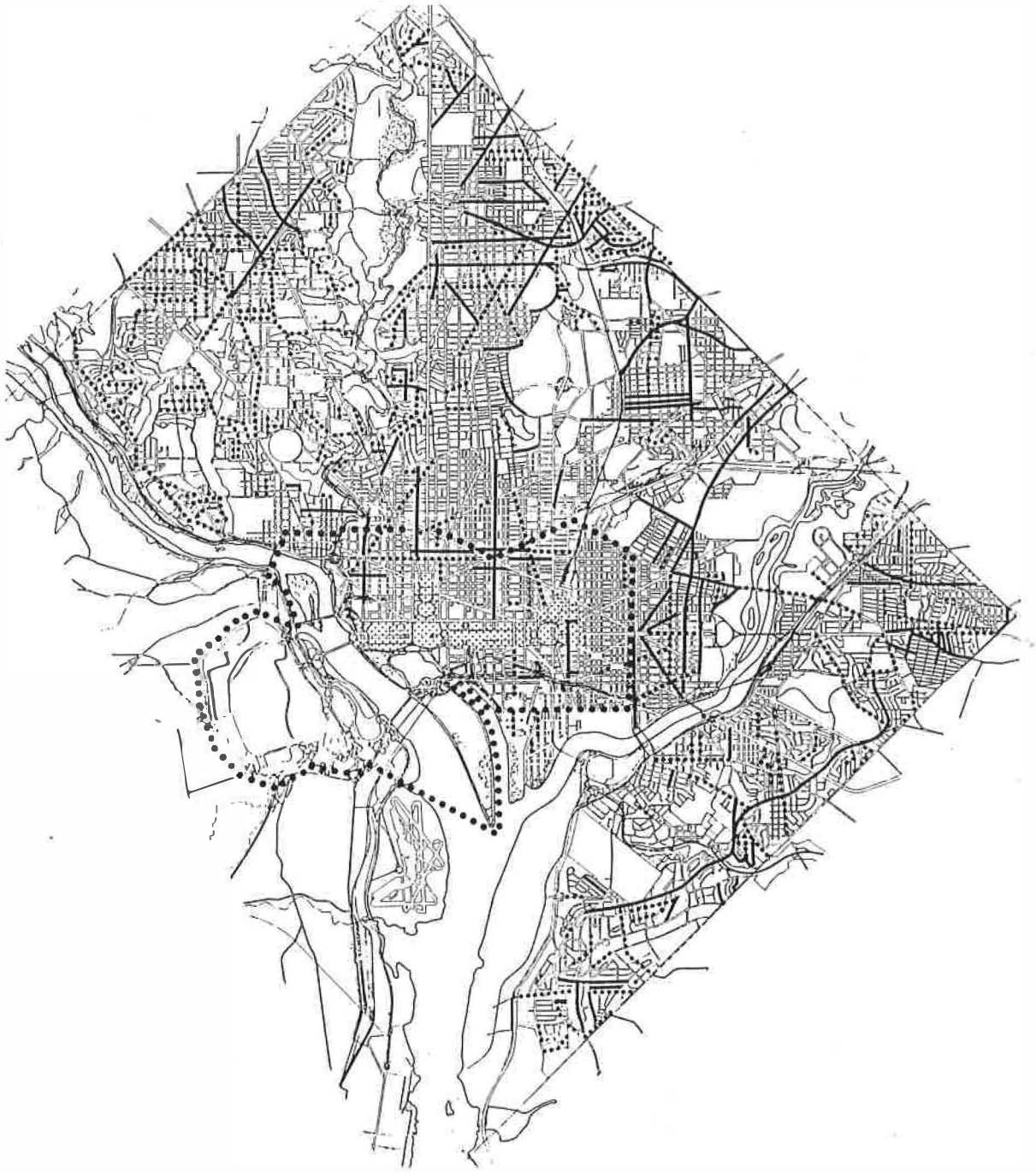
	0	1	2	3	4 or more	TOTAL	Mean years to Removal
Street	0	6	19	12	2	39	2.26
Private	0	1	2	1	0	4	2.00
Other	0	0	2	2	1	5	2.80
Total	0	7	23	15	3	48	2.29

(a) based upon inspections made annually in July between 1981 and 1984.


Emerging adult beetle carrying fungus spores
Beetle carries spores to healthy elm trees
Discolored ring of xylem in infected stem
Mycelium and Cephalosporium-type spores in xylem vessels of elm
Graphium-type conidia
Coremium
Beetle carrying fungus spores
Leaves above infection point wilt
Mycelium and spores in vessels
Ascospores released from perithecium
Ascospores
Beetles breed in elm logs and diseased trees
Healthy elm
Young beetle in tunnel
Diseased elm
Perithecium
Coremia
Perfect stage seldom found in nature
Natural root graft
Fungus grows in elm bark and tunnels
Tunnels of female beetle and larvae in elm bark
Fungus spreads through natural root graft

Disease cycle of Dutch elm disease caused by *Ceratocystis ulmi*.

Appendix F



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Statute Mile

MAINTENANCE POLICY FOR ELM TREES ON D.C. STREETS AND FEDERAL LANDS IN THE DISTRICT OF COLUMBIA

LEGEND:

ZONE I — Monumental Core

Intensive Management Zone

Protective Perimeter

ZONE II — Conventional Management

Street Trees

American Elm to Remain Dominate Tree

American Elm to be Replaced by Other Species

All Other Areas in the District Are Considered to be in the Conventional Management Zone

Natural Areas

May, 1995
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